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(NASA-CR-158130) IDENTIFICATION OF WOOD
ENERGY RESOURCES IN CENTRAL MICHIGAN
(Michigan State Univ.) 37 p HC A03/MF A01

N79-18424

CSCI 02F

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IDENTIFICATION OF WOOD ENERGY RESOURCES
IN CENTRAL MICHIGAN

November 1978

Prepared for the Cooperative Venture of
Wolverine Electric Cooperative
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Consumers Power Company

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NASA Grant NGL 23-004-083

IDENTIFICATION OF WOOD ENERGY RESOURCES IN CENTRAL MICHIGAN

The task of meeting energy needs is particularly important in Michigan, considering its dependence on outside sources of energy (Michigan presently produces only about four percent of its energy requirements). Renewable resources, particularly wood biomass, are being viewed as a highly desirable alternative energy source. While fossil fuels are relatively scarce in Michigan, forests are widely distributed in the state (about half of Michigan's land area is forested). Developments in using wood as a "direct-burn" energy source have progressed to a stage where it is now viewed technically feasible and cost-effective.

A cooperative venture, consisting of Wolverine Electric Cooperative (a publicly-owned electric generation and transmission cooperative), Morbark Industries, Inc. (a forest products firm which manufactures wood-harvesting equipment), and Consumers Power Company (a privately-owned electric and gas utility) is presently planning to build a wood-burning generating plant in west-central Michigan. There is a lack of information on the extent, availability, and location of non-commercial timber resources (standing tree residues, over-stocked stands, logging residues, sites in need of conversion, etc.) which will be used in the power plant. The Remote Sensing Project (RSP) at Michigan State University, in support of this cooperative venture's planning phase to build a wood-burning electrical generating plant, conducted a remote sensing

demonstration project to acquire wood energy resource data. Assistance provided by the Remote Sensing Project is being financially supported by a National Aeronautics and Space Administration (NASA) grant to Michigan State University. The research grant, NASA NGL 23-004-083, is administered by the University Applications Program of the NASA Office of Space and Terrestrial Applications.

Information on the location and quantity of forested acreage in the study area (see Fig. 1) has been extracted from several sources. Existing forest cover type maps, color-infrared aerial photography, LANDSAT satellite imagery, and other recent data sources have been utilized to quantify forested acreage.

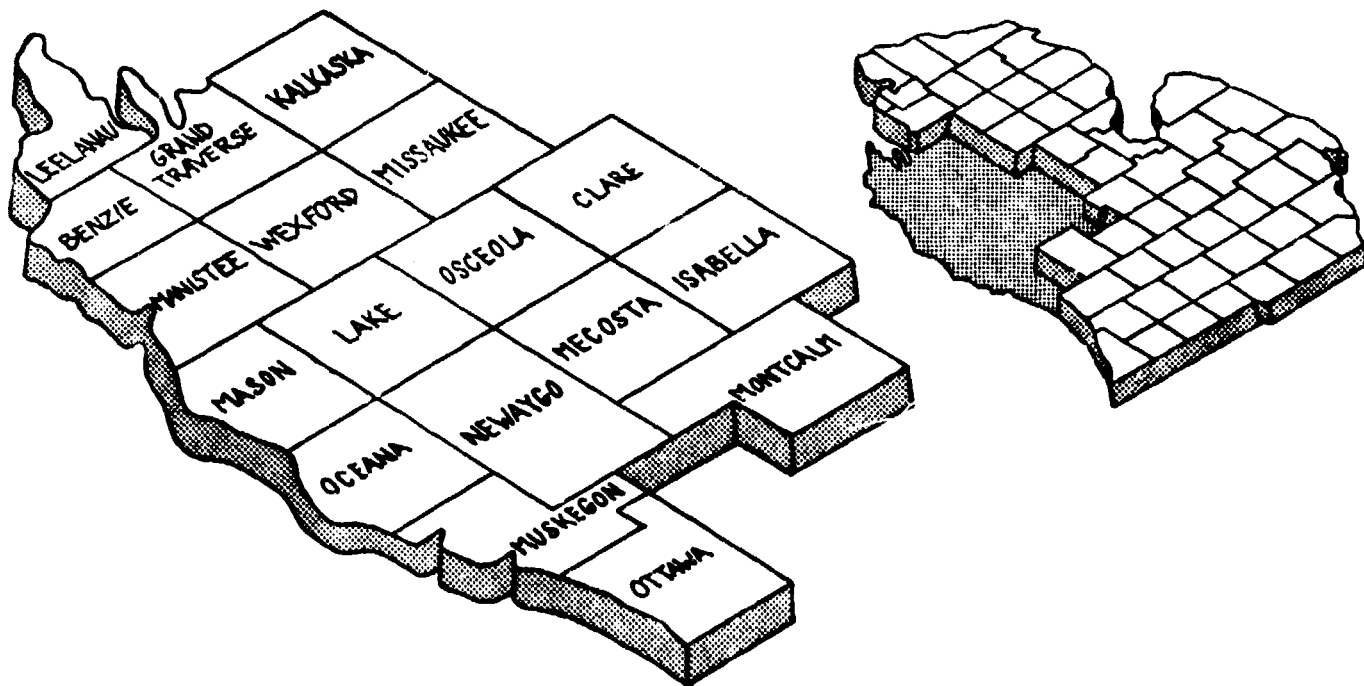


Figure 1.—Wood Energy Resource Study Area.

Forest Data from Color-Infrared Aerial Photography

Information on the location and quantity of forested acreage in the study area (see Fig. 1) has been extracted from several sources. Existing forest cover type maps, LANDSAT satellite data analysis, and other recent data sources have been utilized to quantify forested acreage. The data for Lake, Newaygo, Osceola and Mecosta Counties was compiled from the forest land management and inventory data service maintained by the West Michigan Regional Planning Commission (WMRPC). This system is one of many components of the land planning data bank which comprises the WMRPC's Regional Information System (RIS). The RIS is a computer-oriented program to support local and regional planning efforts. The data bank consists of land-oriented data items (soil type, slope, political boundaries, residential units, etc.) stored with reference to a grid type 10-acre element (Stockman, 1977). Forest cover type information for the four counties was originally interpreted from color-infrared aerial photography and provided in map form under contracts to Environmental Surveys, Inc. (Hudson, 1976 and 1977). A program, developed by the Remote Sensing Project, reads and condenses the geocoded information on the computer tapes and generates summary tables by selected categories. The classification scheme utilized to prepare the type maps is given in Table 1. The area of forest cover types by size and density of stocking, by ownership, for each county is given in tables in the Appendix. Figure 2 is a sample map, produced by the Resource Analysis Program (RAP), a computer information and mapping system (Tilman, 1977), showing the distribution of forest cover types in a portion of Elk Township (T.20N.-R.14W.), Lake County, Michigan.

Table 1.--Classification and Description of Cover Types.

Cover Types Classification	Symbol	Description of Cover Type
Pine	P	The pine species (eastern white pine, red pine, jack pine, or introduced pines) are predominant ¹ singly or in combination.
White Pine	Pw	The predominant species is white pine in a stand primarily of pine.
Red Pine	Pr	The predominant species is red pine in a stand primarily of pine.
Jack Pine	Pj	The predominant species is jack pine in a stand primarily of pine.
Oak	O	The upland oaks are predominant singly or in combination.
Northern Hardwoods	M	The northern hardwood species (sugar maple, beech, basswood, cherry and other upland hardwoods) are predominant singly or in combination.
Aspen-Birch	A	Aspen (quaking aspen, big tooth aspen, and balsam poplar) and/or white birch are predominant.
Lowland Hardwoods	E	The lowland hardwood species (ash, elm, maple and other lowland hardwoods) are predominant singly or in combination.
Conifer Swamps	Q	The swamp conifer species (northern white-cedar, tamarack, and eastern hemlock) are predominant singly or in combination.

¹Predominant--comprises 40% or more of the stocking.

Table 1.--(cont'd.).

Stand Size Classes.

Size Class	Description
Reproduction	Recently harvested, or other non-stocked, forest lands on which tree reproduction is being established either naturally or by planting.
Saplings	Established forest stands with an average height of ten meters or less.
Pole Timber	Forest stands with an average height of between 10 and 20 meters.
Saw Timber	Forest stands with an average height exceeding 20 meters.

Stocking Levels.

Level	Description
Non-Stocked	Recently harvested forest land on which tree reproduction is expected, either naturally or by planting.
Low	Forest stands with between 25% and 50% crown cover.
Medium	Forest stands with between 50% and 75% crown cover.
High	Forest stands with between 75% and 100% crown cover.

Table 1.--(cont'd.).

Stand Size and Stocking Classification.

Stand Size and Stocking	Average Height of Stand in Meters	Per Cent Crown Cover	Symbol
Reproduction/Non- Stocked	0	0	0
Sapling	0-10		
Low		25-50	1
Medium		50-75	2
High		75-100	3
Pole Timber	10-20		
Low		25-50	4
Medium		50-75	5
High		75-100	6
Saw Timber	20+		
Low		25-50	7
Medium		50-75	8
High		75-100	9

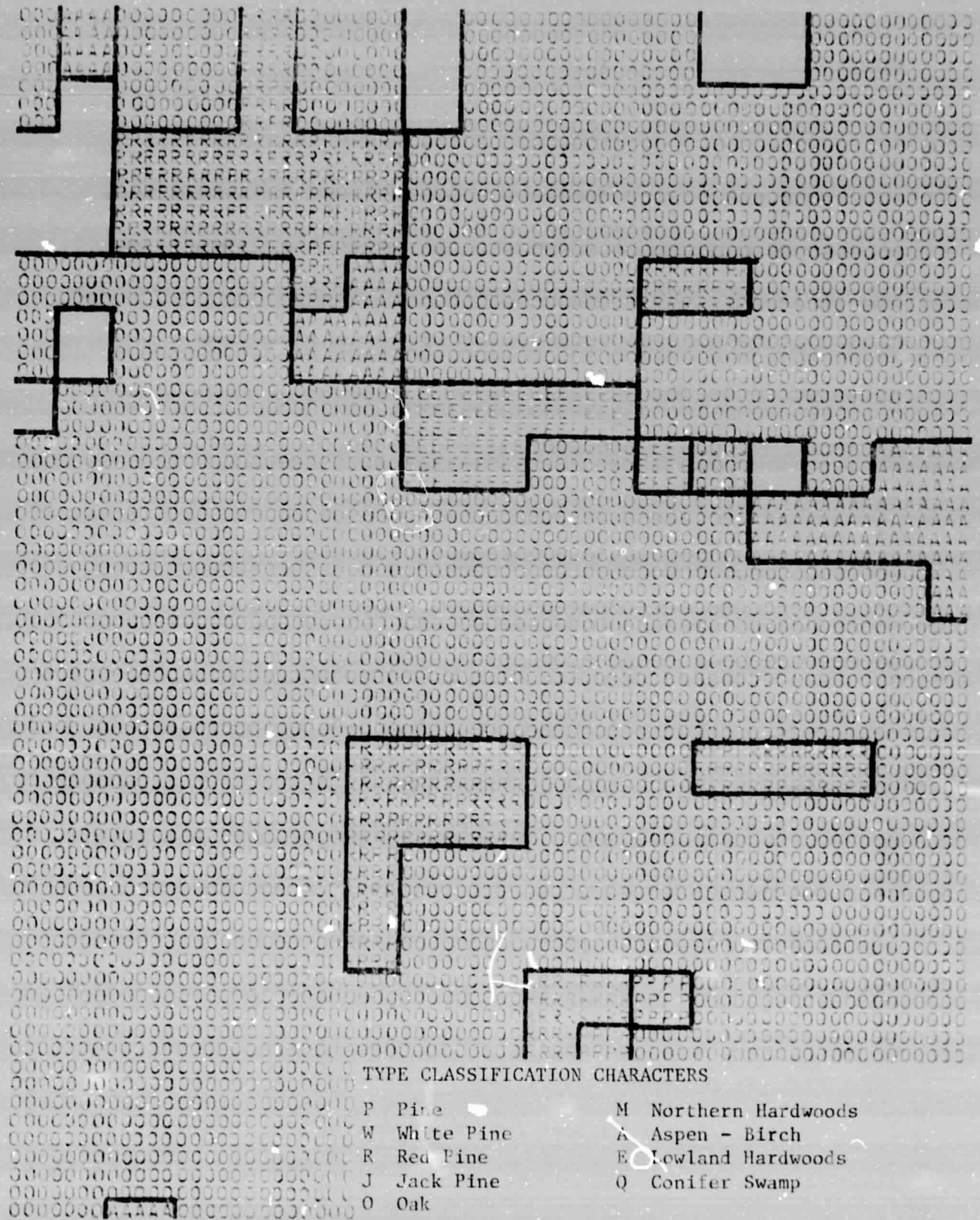


Figure 2.--Sample RAP Map Showing Distribution of Forest Types.

Forest Data from LANDSAT Satellite Imagery

For those counties not covered by the recent photo-derived cover type maps, LANDSAT satellite data were analyzed to update the existing 1966 Forest Survey data. Density analysis of LANDSAT satellite images provided updated estimates of percent, and therefore acreages, of forest cover by county. Preliminary tests indicate that these figures should be better than 90% accurate. The updated acreage estimates were then applied to the 1966 Forest Survey figures to update existing area acreage tables. Tables A17 and A18, in the Appendix, provide area in acres by forest cover types and stand-size classes for Isabella and Clare Counties.

Forest Data from Existing Land Use Maps

For comparative purposes, several additional sources of forest data have been compiled to supplement the above efforts. As part of their normal activities, regional planning commissions have compiled land use maps of various counties within the study area. The West Michigan Regional Planning Commission has produced a four-way classification of forest land in all of its member counties. Table A19, in the Appendix, presents acres of forest land for Mason and Montcalm Counties. The West Michigan Shoreline Regional Development Commission has compiled forest acreage figures for the three counties in its planning region. Table A20, in the Appendix, presents acres of forest land for Muskegon, Oceana, and Ottawa Counties (West Michigan Shoreline Regional Development Commission, undated).

Scotch pine is the most frequently planted tree in Michigan for Christmas trees. Many plantations were established in the late 1950's but were subsequently neglected and have since grown beyond Christmas tree size.

A survey of Scotch pine plantations which have grown beyond Christmas tree size was conducted in the northwest Lower Peninsula (Lemmien and Botti, 1974). The results of this survey for selected counties is given in Table A21 of the Appendix.

Forest Distribution Summary

A graphical summary of the distribution of forest land in the study area is provided in Figure 3. Forest distribution was derived from the depiction of woodland on the U.S.G.S. 1:250,000 map series as provided by the Office of Land Resource Programs, Michigan Department of Natural Resources (MDNR). Also included on the map are the three proposed plant sites with a line indicating a fifty-mile radius from each site. Forest and ownership data as depicted on Figure 3 and on MDNR county maps were geocoded and placed on a computer file. Another RAP routine was executed which calculated the acres of forest land, by ownership, with a specified radius (10, 20, 30, 40 and 50 miles) of each proposed plant site with the results shown in Table 2.

Forest Biomass

After an extensive search of the literature, existing biomass studies were compiled for determining their applicability to the study area. Over sixty tree-weight tables were prepared from existing tables or formulas. A small sample was chosen to provide a "first-cut" estimate of the precision and applicability of the various tree-weight tables. Control plots were established for normal volume data and weight data, harvested and then weighed to determine actual tonnage yields. Table 3 compares the tonnages as derived from the ground cruise and weight tables with actual harvested tonnages.

Table 2.--Acres of Forest Land by Site.

HARLAN

Radius (miles)	Federal	Acres of Forest Land State	Private	Total	% of Area Forested
10	16640	33920	48640	99200	49.3
20	112000	85120	224640	421760	52.4
30	221440	182400	441600	845440	46.7
40	281600	284800	684160	1250560	38.9
50	355840	440320	973440	1769600	35.2

HEPSEY

Radius (miles)	Federal	Acres of Forest Land State	Private	Total	% of Area Forested
10	-0-	11520	20480	32000	15.9
20	33920	50560	227200	311680	38.7
30	224000	96000	524800	844800	46.7
40	364160	170880	879360	1414400	44.0
50	432000	370560	1266560	2069120	41.0

WHITEHALL

Radius (miles)	Federal	Acres of Forest Land State	Private	Total	% of Area Forested
10	8960	1280	68480	78720	39.1
20	30080	8320	155520	193920	24.1
30	62080	10240	229760	302080	16.7
40	149120	12800	377600	539520	16.8
50	225920	30080	528640	784640	15.6

Table 3.--Summary of Predicted vs. Actual Tonnages for Selected Ground Plots.

Plot No./type	Predicted T/A	Harvested T/A	% Error (of prediction)
1/06	90.2	92.1	-2
3/Pr6	128.9	133.5	-3
4/05	93.7	97.8	-4
6+7/04	50.1	49.6	+1
9/Pr6	125.3	126.4	+1
10/Ps3	14.0	26.6	-47
11/Pj6	164.8	132.7	+24

Using the above derived figures as first estimates, tabular and locational estimates of tonnage yields by specified types and areas can be made. Figure 4 is a sample map, produced by the RAP program, showing the tonnage distribution of oak in a portion of Elk Township (T.20N.-R.14W.), Lake County, Michigan. Total biomass for sample forest types are presented in Table 4.

Table 4.--Biomass of Sample Forest Types.

Forest Type	BIOMASS (TONS)				Total
	Lake	Newaygo	Osceola	Mecosta	
04	621,591	710,318	29,008	35,922	1,396,839
05	3,812,840	3,566,784	127,807	260,673	7,768,104
06	4,313,184	3,481,900	231,543	859,425	8,886,052
Pr6	622,329	303,817	418,023	304,204	1,648,373
Pj6	1,939,202	495,389	5,109	20,765	2,460,465
Ps3	--	--	7,294	--	7,294
Total	11,309,146	8,558,208	818,784	1,480,989	22,167,127

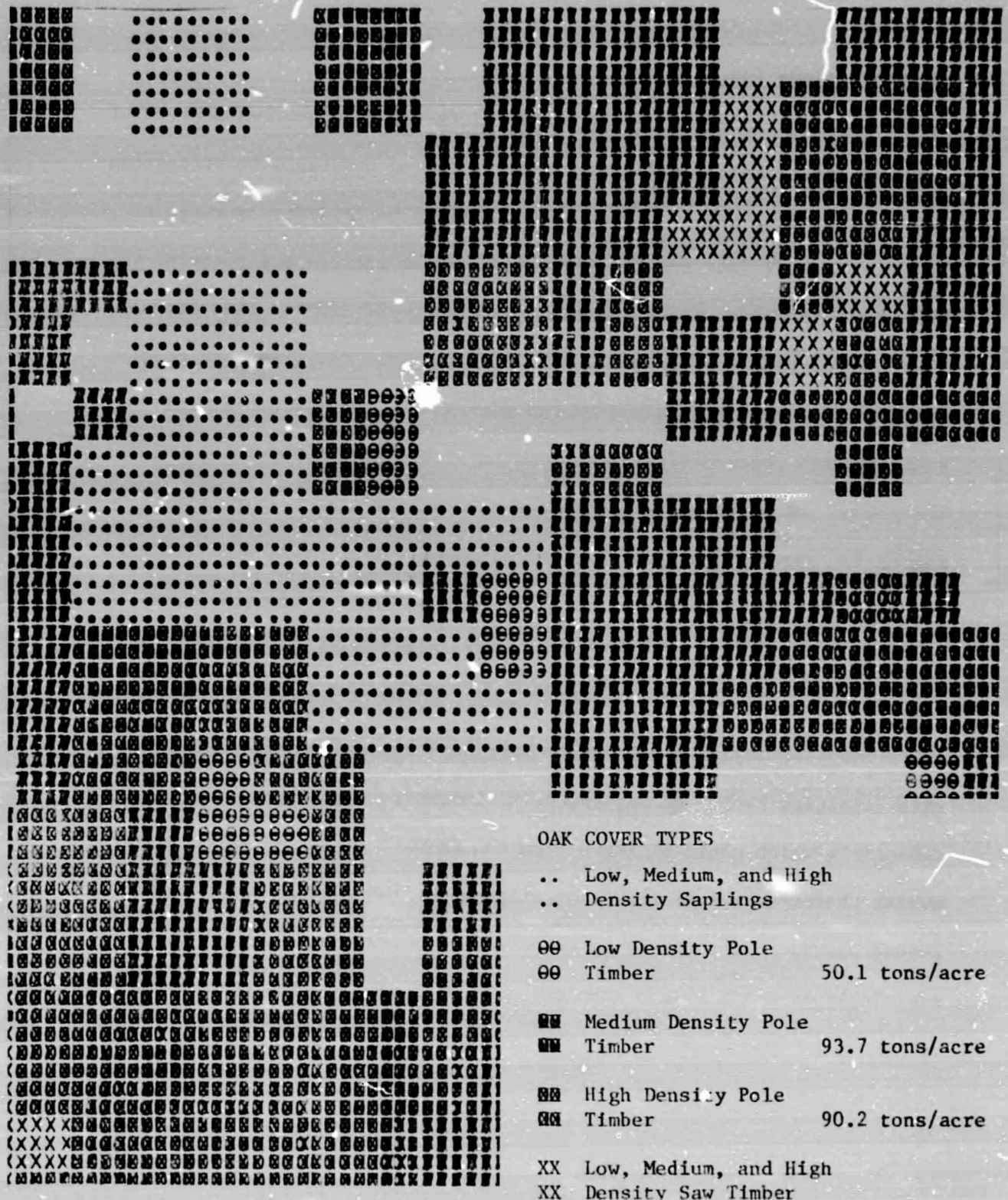


Figure 4.--Sample RAP Map Showing Tonnage Distribution of Oak.

Recommendations for Further Study

Only a limited number of sample plots could be checked because of the time constraints. Additional plots would be desirable to strengthen the existing data and to determine the natural variability or range of values. A sufficient number of plots should be located and measured to sample all the cover types and the entire range of sizes. These same plots should also be located on aerial photographs (e.g. the new color-infrared photography acquired by the Michigan Department of Natural Resources), and photo-derived measurements of the stands should be made. The ground and photo measurements can then be compared by a multiple regression analysis to create an aerial-photo weight prediction table or equation. This table could then be used to predict biomass (from photo measurements alone) for any desired stand. This increased capability would readily lend itself to an inventory of biomass using multi-stage sampling. For instance, a likely project may include a first-stage stratification using LANDSAT satellite images followed by a pyramiding sub-sample which could be drawn from the LANDSAT data, DNR color-infrared aerial photography (using the aerial-photo weight table), and selected ground plots. Continued testing and measurements should result in increasingly accurate weight prediction techniques.

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APPENDIX

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TABLE A1.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

LAKE, NEWAYGO, OSCEOLA, AND MECOSTA COUNTIES--ALL OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS											TOTAL AREA	% OF AREA
	NON-STOCKED	SAPLING			POLE TIMBER				SAW TIMBER				
		0	1	2	3	4	5	6	7	8	9		
Aspen-Birch	481	3755	48231	31893	32373	70953	92514	147	1271	571	282189	31.8	
Lowland Hardwoods	720	2438	5683	1655	26991	28740	20288	3747	13465	1779	105506	11.9	
Oak	1247	3783	14109	4574	27881	82904	98515	5810	26721	4813	270357	30.5	
Northern Hardwoods	19	238	1085	85	3762	8638	18499	2491	11990	5518	52325	5.9	
Jack Pine	61	598	19456	4266	1537	8235	14930	--	--	--	49083	5.5	
White Pine	--	45	3227	1593	432	656	1027	276	1444	154	8854	1.0	
Conifer Swamps	10	1302	6342	1857	2894	5167	6730	200	470	--	24972	2.8	
Pine	1182	6602	17672	8247	685	2447	3633	--	213	32	40713	4.6	
Red Pine	35	1482	13694	16563	696	6841	12788	23	20	64	52206	5.9	
TOTAL	3755	20243	129499	70733	97251	214581	268924	12694	55594	12931	886205		
Percent of Total	0.4	2.3	14.6	8.0	11.0	24.2	30.3	1.4	6.3	1.5		100.0	
Area and % by Size Class		22047.5 acres--24.9%			580756 acres--65.5%				81219 acres--9.2%				

TABLE A2.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

LAKE COUNTY, MICHIGAN--ALL OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS												TOTAL AREA	% OF AREA	
	NON- STOCKED	SAPLING			POLE TIMBER					SAW TIMBER					
		0	1	2	3	4	5	6	7	8	9				
Aspen-Birch	71	715	10487	9710	3509	14081	21268	--	6	26	59873	19.7			
Lowland Hardwoods	357	207	1017	379	4483	6435	5789	766	3854	432	23719	7.8			
Oak	763	2231	8529	3760	12407	40692	47818	2823	11890	2108	133021	43.8			
Northern Hardwoods	--	--	190	15	694	1359	2436	55	570	231	5550	1.8			
Jack Pine	61	495	16583	2991	1256	6130	11767	--	--	--	39283	12.9			
White Pine	--	8	1123	781	100	184	404	45	425	--	3070	1.0			
Conifer Swamps	--	395	2382	591	736	1156	2078	48	254	--	7640	2.5			
Pine	736	1389	6113	1180	328	1472	2095	--	73	--	13386	4.4			
Red Pine	35	422	4213	6141	448	2320	4828	--	18	--	18425	6.0			
TOTAL	2023	5862	50637	25548	23961	73829	98483	3737	17090	2797	303967				
Percent of Total	0.7	1.9	16.7	8.4	7.9	24.3	32.4	1.2	5.6	0.9		100.0			
Area and % by Size Class		82047 acres - 27.0%			196273 acres - 64.6%				23624 acres - 7.7%						

TABLE A3.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

LAKE COUNTY, MICHIGAN--FEDERAL OWNERSHIP

COVER TYPE	SIZE AND STOCKING CLASS											TOTAL AREA	% OF AREA
	NON-STOCKED	SAPLING			POLE TIMBER				SAW TIMBER				
		0	1	2	3	4	5	6	7	8	9		
Aspen-Birch	12	183	2173	3089	1022	2991	5503	—	3	26	15002	14.6	
Lowland Hardwoods	50	20	227	19	873	938	1522	106	1235	89	5079	5.0	
Oak	428	1122	3779	1788	3102	12580	14493	731	3365	1003	42391	41.4	
Northern Hardwoods	—	—	7	—	33	47	91	—	46	13	237	0.2	
Jack Pine	—	95	5880	1667	117	1943	4409	—	—	—	14111	13.8	
White Pine	—	8	1076	749	20	117	318	—	66	—	2354	2.3	
Conifer Swamps	—	69	436	147	87	218	337	—	—	—	1294	1.3	
Pine	274	290	2695	800	100	1268	1867	—	—	—	7294	7.1	
Red Pine	35	351	2522	4666	441	2181	4536	—	—	—	14732	14.4	
TOTAL	799	2138	18795	12925	5795	22283	33076	837	4715	1131	102494		
Percent of Total	0.8	2.1	18.3	12.6	5.6	21.7	32.3	0.8	4.6	1.1		100.0	
Area and % by Size Class		33858 acres - 33.0%			61154 acres - 59.7%				6683 acres - 6.5%				

TABLE A4.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

LAKE COUNTY, MICHIGAN--STATE OWNERSHIP

COVER TYPE	SIZE AND STOCKING CLASS													TOTAL AREA	% OF AREA
	NON-STOCKED	SAPLING				POLE TIMBER				SAW TIMBER					
		0	1	2	3	4	5	6	7	8	9				
Aspen-Birch	27	343	2472	2507	214	1852	5614	---	3	---	---	---	13032	22.3	
Lowland Hardwoods	10	23	213	87	808	1685	1791	273	783	281	---	---	5954	10.2	
Oak	292	421	933	383	2025	5550	10717	865	1619	489	---	---	23294	39.9	
Northern Hardwoods	---	---	---	---	---	144	188	---	20	---	---	---	352	0.6	
Jack Pine	61	130	2887	582	744	2861	3184	---	---	---	---	---	10449	18.0	
White Pine	---	---	32	10	21	50	39	13	95	---	---	---	260	0.4	
Conifer Swamps	---	123	903	133	178	337	942	25	45	---	---	---	2686	4.6	
Pine	323	71	638	36	139	42	37	---	17	---	---	---	1303	2.2	
Red Pine	---	17	444	459	---	1	86	---	18	---	---	---	1025	1.8	
TOTAL	713	1128	8522	4197	4129	12522	22598	1176	2600	770	---	---	58355	---	
Percent of Total	1.2	1.9	14.6	7.2	7.1	21.5	38.7	2.0	4.4	1.3	---	---	---	100.0	
Area and % by Size Class	13847 acres - 23.7%				39249 acres - 67.3%				4546 acres - 7.8%						

TABLE A5.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

LAKE COUNTY, MICHIGAN--PRIVATE OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS												TOTAL AREA	Z OF AREA
	NON-STOCKED	SAPLING			POLE TIMBER				SAW TIMBER					
		1	2	3	4	5	6	7	8	9				
Aspen-Birch	32	189	5842	4114	2273	9238	10151	---	---	---	31839	22.2		
Lowland Hardwoods	297	164	577	273	2802	3812	2476	387	1836	62	12686	8.9		
Oak	43	688	3817	1589	7280	22562	22608	1227	6906	616	67336	47.0		
Northern Hardwoods	---	---	183	15	661	1168	2157	55	504	218	4961	3.5		
Jack Pine	---	270	7816	742	395	1326	4174	---	---	---	14723	10.3		
White Pine	---	---	15	22	59	17	47	32	264	---	456	0.3		
Conifer Swamps	---	203	1043	311	471	601	799	23	209	---	3660	2.6		
Pine	139	1028	2780	344	89	162	191	---	56	---	4789	3.3		
Red Pine	---	54	1247	1016	7	138	206	---	---	---	2668	1.9		
TOTAL	511	2596	23320	8426	14037	39024	42809	1724	9775	896	143118			
Percent of Total	0.4	1.8	16.3	5.9	9.8	27.3	29.9	1.2	6.8	0.6		100.0		
Area and % by Size Class		34342 acres - 24.0%			95870 acres - 67.0%				12395 acres - 8.7%					

TABLE A6.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

NEWAYGO COUNTY, MICHIGAN--ALL OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS											TOTAL AREA	% OF AREA
	NON-STOCKED	SAPLING			POLE TIMBER			SAW TIMBER					
		1	2	3	4	5	6	7	8	9			
Aspen-Birch	43	1720	25570	8153	13902	24257	20618	102	137	37	94539	31.5	
Lowland Hardwoods	363	1064	2757	1101	11198	8912	8231	1402	4822	497	40347	13.5	
Oak	476	1218	4879	751	14178	38066	38602	1231	2860	1107	103368	34.5	
Northern Hardwoods	---	16	644	---	607	1354	2956	268	317	45	6207	2.1	
Jack Pine	---	100	2860	1261	281	2050	3006	---	---	---	9558	3.2	
White Pine	---	37	1946	628	146	132	112	51	271	132	3455	1.1	
Conifer Swamps	10	443	1874	433	675	1361	1778	131	88	---	6793	2.3	
Pine	113	3474	9162	2466	151	435	287	---	140	32	16260	5.4	
Red Pine	---	254	7270	4981	137	4110	2357	14	---	64	19187	6.4	
TOTAL	1005	8326	56962	19774	41275	80677	77947	3199	8635	1914	299714		
Percent of Total	0.3	2.8	19.0	6.6	13.8	26.9	26.0	1.1	2.9	0.6		100.0	
Area and % by Size Class		81062 acres - 28.4%			199899 acres - 66.7%			13748 acres - 4.6%					

TABLE A7.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

NEWAYGO COUNTY, MICHIGAN--FEDERAL OWNERSHIP

COVER TYPE	SIZE AND STOCKING CLASS													TOTAL AREA	% OF AREA
	NON- STOCKED	SAPLING			POLE TIMBER				SAW TIMBER						
		1	2	3	4	5	6	7	8	9					
Aspen-Birch	1	680	8532	2769	2162	4823	4417	4	43	8			23439	24.6	
Lowland Hardwoods	22	272	549	276	2436	2410	2230	725	1622	300			10842	11.4	
Oak	306	672	1402	181	4022	11624	11665	625	1093	232			31822	33.4	
Northern Hardwoods	--	--	58	--	11	22	139	11	19	--			260	0.3	
Jack Pine	--	52	1873	1017	208	1845	2820	--	--	--			7815	8.2	
White Pine	--	--	1781	548	30	17	10	10	30	43			2469	2.6	
Conifer Swamps	--	122	567	88	185	434	660	19	30	--			2105	2.2	
Pine	49	407	1934	386	43	261	212	---	---	---			3292	3.5	
Red Pine	--	65	4162	3112	4	3594	2131	14	--	64			13146	13.8	
TOTAL	378	2270	20858	8377	9101	25030	24284	1408	2837	647			95190		
Percent of Total	0.4	2.4	21.9	8.8	9.6	26.3	25.5	1.5	3.0	0.7				100.0	
Area and % by Size Class		31505 acres - 33.1%			58415 acres - 61.4%				4892 acres - 5.1%						

TABLE A8.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

NEWAYGO COUNTY, MICHIGAN--STATE OWNERSHIP

COVER TYPE	SIZE AND STOCKING CLASS													TOTAL AREA	Z OF AREA	
	NON- STOCKED	SAPLING					POLE TIMBER					SAW TIMBER				
		0	1	2	3	4	5	6	7	8	9					
Aspen-Birch	--	--	73	5	61	58	37	--	--	--	--	--	234	37.0		
Lowland Hardwoods	--	--	--	--	--	46	--	--	--	--	--	--	46	7.3		
Oak	1	24	--	--	35	94	119	--	--	--	--	--	273	43.2		
Northern Hardwoods	--	--	--	--	--	--	--	--	--	--	--	--	--	--		
Jack Pine	--	--	9	12	--	--	--	--	--	--	--	--	21	3.3		
White Pine	--	--	--	--	1	--	--	--	--	--	--	--	1	0.2		
Conifer Swamps	--	--	18	--	5	9	12	--	--	--	--	--	44	7.0		
Pine	--	--	12	--	--	--	--	--	--	--	--	--	12	1.9		
Red Pine	--	--	--	--	--	--	1	--	--	--	--	--	1	0.2		
TOTAL	1	24	112	17	102	207	169	--	--	--	--	--	632			
Percent of Total	0.2	3.8	17.7	2.7	16.1	32.7	26.7	--	--	--	--	--		100.0		
Area and % by Size Class		153 acres - 24.2%					478 acres - 75.6%									

TABLE A9.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

NEWAYGO COUNTY, MICHIGAN--PRIVATE OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS											TOTAL AREA	% OF AREA	
	NON- STOCKED	SAPLING				POLE TIMBER				SAW TIMBER				
		1	2	3	4	5	6	7	8	9				
Aspen-Birch	42	1040	16965	5379	11679	19376	16164	98	94	29	70866	34.8		
Lowland Hardwoods	341	792	2208	825	8762	6456	6001	677	3200	197	29459	14.4		
Oak	169	522	3477	570	10121	26348	26818	606	1767	875	71273	35.0		
Northern Hardwoods	--	16	586	--	596	1332	2817	257	298	45	5947	2.9		
Jack Pine	--	48	978	232	73	205	186	--	--	--	1722	0.8		
White Pine	--	37	165	80	115	115	102	41	241	89	985	0.5		
Conifer Swamps	10	321	1289	345	485	918	1106	112	58	--	4644	2.3		
Pine	64	3067	7216	2080	108	174	75	--	140	32	12956	6.3		
Red Pine	--	189	3108	1869	133	516	225	--	--	--	6040	3.0		
TOTAL	626	6032	35992	11380	32072	55440	53494	1791	5798	1267	203892			
Percent of Total	0.3	3.0	17.6	5.6	15.7	27.2	26.2	0.9	2.8	0.6		100.0		
Area and % by Size Class		53404 acres - 26.2%				141006 acres - 69.2%				8856 acres - 4.3%				

TABLE A10.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING
OSCEOLA COUNTY, MICHIGAN--ALL OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS															TOTAL AREA	Z OF AREA
	NON- STOCKED	SAPLING				POLE TIMBER					SAW TIMBER						
		0	1	2	3	4	5	6	7	8	9						
Aspen-Birch	347	770	7923	8624	11688	22195	24739	37	882	109					77314	48.8	
Lowland Hardwoods	--	669	1045	32	6433	7170	1247	1152	3468	261					21477	13.5	
Oak	--	145	320	--	579	1364	2567	1185	7512	894					14575	9.2	
Northern Hardwoods	19	57	130	5	1614	3675	7522	1624	7754	2820					25220	15.9	
Jack Pine	--	1	10	11	--	55	31	--	--	--					108	0.1	
White Pine	--	--	--	--	3	44	58	30	440	--					575	0.4	
Conifer Swamps	--	242	1543	570	847	1448	727	12	128	--					5517	3.5	
Pine	231	1340	1276	2372	159	273	786	--	--	--					6437	4.1	
Red Pine	--	561	1027	2219	60	180	3243	6	--	--					7296	4.6	
TOTAL	597	3785	13283	13833	21383	36404	40920	4046	20184	4084					158519		
Percent of Total	0.4	2.4	8.4	8.7	13.5	23.0	25.8	2.5	12.7	2.6						100.0	
Area and % by Size Class	30901 acres--19.5%				98707 acres--62.3%				28314 acres--17.9%								

TABLE A11.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING
OSCEOLA COUNTY, MICHIGAN--STATE OWNERSHIP

COVER TYPE	SIZE AND STOCKING CLASS														TOTAL AREA	Z OF AREA
	NON-STOCKED	SAPLING				POLE TIMBER				SAW TIMBER						
		0	1	2	3	4	5	6	7	8	9					
Aspen-Birch	213	60	1235	2827	421	988	4579	--	114	--			10437	69.9		
Lowland Hardwoods	--	18	7	--	44	172	17	3	14	--			275	1.8		
Oak	--	37	133	--	37	202	933	163	1885	265			3655	24.5		
Northern Hardwoods	--	9	47	--	1	58	67	15	48	--			245	1.6		
Jack Pine	--	--	--	11	--	25	31	--	--	--			67	0.4		
White Pine	--	--	--	--	--	--	--	--	23	--			23	0.1		
Conifer Swamps	--	8	--	--	15	--	--	--	--	--			23	0.1		
Pine	--	16	36	32	--	--	--	--	--	--			84	0.6		
Red Pine	--	38	27	25	--	--	40	--	--	--			130	0.9		
TOTAL	213	186	1485	2895	518	1445	5667	181	2084	265			14939			
Percent of Total	1.4	1.2	9.9	19.4	3.5	9.7	37.9	1.2	14.0	1.8				100.0		
Area and % by Size Class	4566 acres--30.6%				7630 acres--51.1%				2530 acres--16.9%							

TABLE A12.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING
OSCEOLA COUNTY, MICHIGAN--PRIVATE OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS													TOTAL AREA	% OF AREA
	NON- STOCKED	SAPLING			POLE TIMBER					SAW TIMBER					
		1	2	3	4	5	6	7	8	9					
Aspen-Birch	134	710	6688	5797	11267	21207	20160	37	768	109				66877	46.6
Lowland Hardwoods	--	651	1038	32	6389	6998	1230	1149	3454	261				21202	14.8
Oak	--	108	196	--	542	1162	1634	1022	5627	629				10920	7.6
Northern Hardwoods	19	48	83	5	1613	3617	7455	1609	7706	2820				24975	17.4
Jack Pine	--	1	10	--	--	30	--	--	--	--				41	0.0
White Pine	--	--	--	--	3	44	58	30	417	--				552	0.4
Conifer Swamps	--	234	1543	570	832	1448	727	12	128	--				5494	3.8
Pine	231	1324	1240	2340	159	273	786	--	--	--				6353	4.4
Red Pine	--	523	1000	2194	60	180	3203	6	--	--				7166	5.0
TOTAL	384	3599	11798	10938	20865	34959	35253	3865	18100	3819				143580	
Percent of Total	0.3	2.5	8.2	7.6	14.5	24.3	24.6	2.7	12.6	2.7					100.0
Area and % by Size Class		26335 acres--18.3%			91077 acres--63.4%				25784 acres--18.0%						

TABLE A13.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

MECOSTA COUNTY, MICHIGAN--ALL OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS												TOTAL AREA	Z OF AREA
	NON-STOCKED	SAPLING			POLE TIMBER			SAW TIMBER						
		0	1	2	3	4	5	6	7	8	9			
Aspen-Birch	20	550	4251	5406	3274	10420	25889	8	246	399	50463	40.7		
Lowland Hardwoods	--	498	864	143	4877	6223	5021	427	1321	589	19963	16.1		
Oak	8	189	372	63	717	2782	9528	571	4459	704	19393	15.6		
Northern Hardwoods	--	165	121	65	847	2250	5585	544	3349	2422	15348	12.4		
Jack Pine	--	2	3	3	--	--	126	--	--	--	134	0.1		
White Pine	--	--	158	184	183	296	453	150	308	22	1754	1.4		
Conifer Swamps	--	222	543	263	636	1202	2147	9	--	--	5022	4.0		
Pine	102	399	1121	2229	47	267	465	--	--	--	4630	3.7		
Red Pine	--	245	1184	3222	51	231	2360	3	2	--	7298	5.9		
TOTAL	130	2270	8617	11578	10632	23671	51574	1712	9685	4136	124005			
Percent of Total	0.1	1.8	6.9	9.3	8.6	19.1	41.6	1.4	7.8	3.3		100.0		
Area and Z by Size Class		22465 acres--18.1%			85877 acres--69.3%			15533 acres--12.5%						

TABLE A14.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

MECOSTA COUNTY, MICHIGAN--FEDERAL OWNERSHIP

COVER TYPE	SIZE AND STOCKING CLASS														TOTAL AREA	% OF AREA
	NON- STOCKED	SAPLING				POLE TIMBER				SAW TIMBER						
		1	2	3	4	5	6	7	8	9						
Aspen-Birch	0	--	23	20	--	--	200	--	--	--	9				263	11.1
Lowland Hardwoods	--	--	--	--	22	9	6		12	--	--				49	2.1
Oak	6	59	177	--	18	160	345	40	274	30					1109	46.9
Northern Hardwoods	--	--	--	--	--	11	21	9	--	--	--				41	1.7
Jack Pine	--	2	--	3	--	--	119	--	--	--	--				124	5.2
White Pine	--	--	23	--	3	--	--	2	--	--	--				28	1.2
Conifer Swamps	--	--	1	--	5	--	--	--	--	--	--				6	0.2
Pine	--	19	--	--	--	--	--	--	--	--	--				19	0.8
Red Pine	--	13	309	176	--	28	201	--	--	--	--				727	30.7
TOTAL	26	93	533	199	48	208	892	51	286	30					2366	
Percent of Total	1.1	3.9	22.5	8.4	2.0	8.8	37.7	2.2	12.1	1.3						100.0
Area and % by Size Class		825 acres--34.9%				1148 acres--48.5%				367 acres--15.5%						

TABLE A15.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING

MECOSTA COUNTY, MICHIGAN--STATE OWNERSHIP

COVER TYPE	SIZE AND STOCKING CLASS											TOTAL AREA	% OF AREA
	NON-STOCKED	SAPLING			POLE TIMBER				SAW TIMBER				
		0	1	2	3	4	5	6	7	8	9		
Aspen-Birch	--	116	467	1085	203	668	2573	--	--	--	--	5112	66.4
Lowland Hardwoods	--	64	26	2	158	142	201	--	--	67	--	660	8.6
Oak	--	--	--	--	47	107	415	--	--	181	--	750	9.7
Northern Hardwoods	--	--	--	--	26	8	58	12	66	--	--	170	2.2
Jack Pine	--	--	--	--	--	--	--	--	--	--	--	--	--
White Pine	--	--	--	--	--	--	--	--	18	--	--	18	0.2
Conifer Swamps	--	132	122	13	36	154	225	--	--	--	--	682	8.9
Pine	--	1	--	50	--	24	--	--	--	--	--	75	1.0
Red Pine	--	--	30	72	7	105	15	--	--	--	--	229	3.0
TOTAL	--	313	645	1222	477	1208	3487	12	332	--	--	7696	
Percent of Total	--	4.1	8.4	15.9	6.2	15.7	45.3	0.2	4.3	--	--		100.0
Area and % by Size Class		2180 acres--28.3%			5172 acres--67.2%				344 acres--4.5%				

TABLE A16.

AREA IN ACRES OF FOREST COVER TYPES BY SIZE CLASS AND DENSITY OF STOCKING
MECOSTA COUNTY, MICHIGAN--PRIVATE OWNERSHIPS

COVER TYPE	SIZE AND STOCKING CLASS											TOTAL AREA	% OF AREA	
	NON-STOCKED	SAPLING				POLE TIMBER				SAW TIMBER				
		1	2	3	4	5	6	7	8	9				
Aspen-Birch	--	434	3761	4301	3071	9752	23116	8	246	399		45088	39.6	
Lowland Hardwoods	--	434	838	141	4697	6072	4814	427	1242	589		19254	16.9	
Oak	2	130	195	63	652	2515	8768	531	4004	674		17534	15.4	
Northern Hardwoods	--	165	121	65	821	2231	5506	523	3283	2422		15137	13.3	
Jack Pine	--	--	3	--	--	--	7	--	--	--		10	0.0	
White Pine	--	--	135	184	180	296	453	148	290	22		1708	1.5	
Conifer Swamps	--	90	420	250	595	1048	1922	9	--	--		4334	3.8	
Pine	102	379	1121	2179	47	243	465	--	--	--		4536	4.0	
Red Pine	--	232	845	2974	44	98	2144	3	2	--		6342	5.6	
TOTAL	104	1864	7439	10157	10107	22255	47195	1649	9067	4106		113943		
Percent of Total	0.1	1.6	6.5	8.9	8.9	19.5	41.4	1.4	8.0	3.6			100.0	
Area and % by Size Class		19460 acres--17.1%				79557 acres--69.8%				14822 acres--13.0%				

AREA IN ACRES BY FOREST COVER TYPES AND STAND-SIZE CLASSES

TABLE A17.--ISABELLA COUNTY, MICHIGAN
1966 Forest Survey Data Updated from LANDSAT Satellite Data Analysis

COVER TYPE	NON-STOCKED	SAPLING	POLE TIMBER	SAW TIMBER	TOTAL AREA	% OF AREA
Aspen-Birch	910	13559	18291	3640	36400	41.2
Lowland Hardwoods	637	3640	5733	4732	14742	16.7
Oak	91	2002	5915	3276	11284	12.8
Northern Hardwoods	--	3276	7826	5187	16289	18.4
Jack Pine	--	182	546	--	728	0.8
White Pine	--	--	--	182	182	0.2
Conifer Swamps	91	1820	3367	273	5551	6.3
Scotch Pine	--	1183	--	--	1183	1.3
Red Pine	--	1456	273	273	2002	2.3
TOTAL	1729	27118	41951	17563	88361	
Percent of Total	2.0	30.7	47.5	19.9		100.0

TABLE A18.--CLARE COUNTY, MICHIGAN

1966 Forest Survey Data Updated from LANDSAT Satellite Data Analysis

COVER TYPE	NON-STOCKED	SAPLING	POLE TIMBER	SAW TIMBER	TOTAL AREA	% OF AREA
Aspen-Birch	3192	45353	62377	11305	122227	40.1
Lowland Hardwoods	1330	8512	11305	13300	34447	11.3
Oak	1862	8246	19950	9975	40033	13.1
Northern Hardwoods	931	11970	44821	16296	73948	24.3
Jack Pine	266	1463	1862	133	3724	1.2
White Pine	--	--	--	931	931	0.3
Conifer Swamps	399	6384	11837	2394	21014	7.0
Scotch Pine	--	1596	--	--	1596	0.5
Red Pine	--	3857	1596	1197	6650	2.2
TOTAL	7980	87381	153748	55461	304570	
Percent of Total	2.6	28.7	50.5	18.2		100.0

TABLE A19.--Acres of Forest Land in Mason and Montcalm Counties.*

	Mason County	Montcalm County
Hardwood	91,837	75,345
Conifer	19,277	10,072
Hardwood/Conifer	23,740	3,010
Wooded Wetland	<u>28,675</u>	<u>40,427</u>
Total	163,529	128,854

* John Dean, West Michigan Regional Planning Commission, personal communications.

TABLE A20.--Acres of Forest Land in Muskegon, Oceana, and Ottawa Counties.

	Muskegon County	Oceana County	Ottawa County
% Forested	46.8	48.2	24.2
Total Land Area	332,160	346,240	366,080
Acres Forested	155,451	166,888	87,859

TABLE A21.--Scotch Pine Survey in the Northwest Lower Peninsula.

County	Plantations Sampled	Average Plantation Size	Estimated Total Area in Scotch Pine Plantations
Benzie	10	6.2	1,240
Grand Traverse	9	2.6	569
Kalkaska	11	8.7	2,316
Lake	0	---	---
Leelanau	12	2.3	710
Manistee	3	19.2	1,698
Mason	17	4.9	2,053
Missaukee	16	8.3	3,184
Osceola	5	3.8	521
Wexford	<u>6</u>	<u>6.6</u>	<u>863</u>
Total	89	6.1	13,154